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Abstract:

This study investigated whether two different versions of an online professional development course produced different impacts on the intended outcomes of the course. Variations of an online course for middle school algebra teachers were created for two experimental conditions. One was an actively facilitated course with asynchronous peer interactions among participants. The second was a self-paced condition, in which neither active facilitation nor peer interactions were available. Both conditions showed significant impact on teachers' mathematical understanding, pedagogical beliefs, and instructional practices. Surprisingly, the positive outcomes were comparable for both conditions. Further research is needed to determine whether this finding is limited to self-selected teachers, the specifics of this online course, or other factors that limit generalizability.

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Online Courses for Math Teachers: Comparing Self-Paced and Facilitated Cohort Approaches

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Introduction

There has been a dramatic increase in online professional development (OPD) programs for teachers across the country, with offerings from colleges and universities, school districts, regional service providers, state departments of education, and other non-profit and for-profit providers (Dede, 2006; Galley, 2002; Keller, 2005). These programs have taken on a wide variety of models and formats as the number of online courses has expanded. For example, OPD opportunities today include single-session workshops, semester-long courses, and extended interactions with online peers or mentors over time; they may involve individual study programs or participation in online professional communities; they may also incorporate a variety of communication methods and media, such as shared online workspaces, asynchronous discussion boards, webcasts, videoconferencing, and a mix of face-to-face and online interaction (Dede, 2006; Treacy, Kleiman, & Peterson, 2002).

Prolific expansion in the number and types of OPD programs has raised concerns about the quality of existing offerings and strong interest in guidelines for the design of effective online courses for teachers (Keller, 2005; National Staff Development Council, 2001). In a recent review of empirical research conducted over the past decade, Whitehouse, Breit, McCloskey, Ketelhut, & Dede (2006) found that past studies of OPD have focused on documenting the designs, methods of implementation, and correlates of OPD programs, but have not been designed to establish valid causal links between specific OPD designs and teacher and student outcomes. A majority of studies of online learning have been based on higher

education courses, where the most common finding has been no significant difference in college-student learning between those in face-to-face and online courses (Phipps & Merisotis, 1999; Russell, 1999).

Within the field of traditional *face-to-face* teacher professional development, researchers and practitioners have built upon a substantial body of research to agree on a consistent set of characteristics associated with effective design and practice (Sparks, 2002). Traditional single-day workshops and courses that focus on abstract teaching principles are inadequate, researchers argue; more powerful professional development involves ongoing, concrete classroom support that is integrated into teachers' daily practice. Through activities such as regular peer coaching and shared lesson planning, teachers improve their professional knowledge and skills while addressing the specific learning needs of their students and the challenges posed by their specific school contexts (Darling-Hammond, 1997; Renyi, 1996; Sparks, 2002; Stigler & Hiebert, 1999). Effective professional development focuses on the subjects that teachers teach, is aligned with local curriculum standards, deepens teachers' content knowledge, and fosters active and inquiry-based forms of learning (Ball & Cohen, 1999; Loucks-Horsley, 1995; Scotchmer, McGrath, & Coder, 2005; Sparks, 2002; Willis, 2002). At the same time, high-quality professional development targets a small set of student learning goals and is centered on improving student outcomes rather than meeting teacher interests (Loucks-Horsley, 1995; Sparks, 2002).

Another key feature of effective face-to-face professional development is teacher collaboration. Teacher groups that form to exchange knowledge, advice, and support for improving classroom teaching and student learning have been given names such as learning communities, professional communities, communities of practice, and communities of inquiry (Barab, MaKinster, & Scheckler, 2003; Dalgarno & Colgan, 2007; DuFour, 2002; Lim, 2004; Louis & Marks, 1998; Nickerson & Sowder, 2002). Researchers argue that membership in collaborative learning communities is critical for teacher professional development, because ongoing discussion with peers encourages analytical and reflective thinking and helps to spread the "wisdom of practice" (Ball & Cohen, 1999; Schulman, 1987). When teachers develop open and trusting relationships with community colleagues, they begin to feel less isolated, more willing to work together to tackle student issues, and more open to experiment and to take risks with methods of instruction (Dalgarno & Colgan, 2007; DuFour, 2002). Some researchers have found statistically significant relationships between the presence of professional communities and higher student achievement, arguing that strong teacher collaboration supports the use of pedagogical methods that can promote deeper student learning (Louis & Marks, 1998).

While the research on OPD is far less extensive, OPD programs can seek to incorporate characteristics associated with effective face-to-face professional development while offering a number of potential advantages over face-to-face formats. Because Internet access has become nearly universal in K–12 schools and widespread in teachers' homes, OPD provides teachers with opportunities to engage in forms of training that may not be available within their local areas. Teachers can participate in professional development during times that are convenient; receive job-embedded support that addresses immediate classroom needs; customize programs to better suit their own individual learning styles; interact with material through a variety of visual or other multi-media formats; and gain valuable computer and online technology skills (Docherty & Sandhu, 2006; Garrison & Cleveland-Innes, 2005; National Staff Development Council, 2001; Richardson, 2002; Spicer, 2002; Treacy, Kleiman, & Peterson, 2002).

Due to its accessible and flexible modes of communication, OPD can also support the growth and maintenance of teacher learning communities. The internet can connect teachers to broad networks of professionals, providing them with access to a wide array of learning experiences, and helping to reduce the isolation that has often accompanied traditional forms of classroom teaching (DuFour, 2002; National Staff Development Council, 2001). Some researchers and educators argue that OPD can promote deeper levels of communication and thought among teachers than face-to-face forms of professional development. Because online programs can store written records of teacher conversations, and because teachers can participate in group discussion asynchronously, OPD allows teachers to contribute ideas when they are ready and to be more reflective in their written, online comments (Spicer, 2002; Treacy, Kleiman, & Peterson, 2002). For sensitive topics, online discussion boards can sometimes foster more open and uninhibited dialogue (Spicer, 2002). By providing teachers with the ongoing ability to communicate online, OPD can strengthen professional relationships that are created face-to-face and can support ongoing teacher collaboration after a course ends (Anderson, 2002; Dalgarno & Colgan, 2007; Garrison & Cleveland-Innes, 2005; Treacy, Kleiman, & Peterson, 2002).

While OPD has the potential to facilitate collaboration, there are also many challenges in fostering successful online collaborations. Researchers argue that truly collaborative teacher cultures and sustainable learning communities cannot be designed, created, or controlled through outside forces; they must be member-driven, involve voluntary participation, and evolve to meet the needs of members over time (Barab, MaKinster, & Scheckler, 2003; Hargreaves, 1994; Henderson, 2007). Research has

shown that building learning communities online can take long periods of time and require significant energy and input from course designers and facilitators (Hur & Hara, 2007; Lim, 2004; Schlager, Fusco, & Schank, 2002). Access to varied forms of communication and a high quantity of teacher interaction is insufficient for the development of effective learning communities. Instead, designers of professional development must promote teacher interaction that is structured, purposeful, substantive, and engaging in order to deliver high quality support and stimulate deeper professional growth (Ball, 2002; Garrison & Cleveland-Innes, 2005).

Researchers and practitioners therefore suggest that for OPD to reach its full potential, programs must offer content and skills training that are directly relevant to teachers' immediate classroom needs. They must contain a variety of activities to engage learners; allow asynchronous online discussion to allow for varied schedules; provide multiple opportunities for teacher reflection; employ skilled online course facilitators; and give teachers the ability to continue collaboration after the course ends (Anderson, 2002; Dalgarno & Colgan, 2007; Florida Instructional Technology Resource Center at UCF, 2000; Lim, 2004). To build sustainable online learning communities, researchers suggest that designers work with teachers to co-develop course content and topics of discussion (Barab, MaKinster, & Scheckler, 2003; Dalgarno & Colgan, 2007). Researchers have found close emotional and personal connections among members of enduring professional communities. To help build such connections, some writers suggest that OPD developers incorporate face-to-face sessions within their courses and provide online discussion spaces in which teachers can interact more socially and informally (Florida Instructional Technology Resource Center at UCF, 2000; Galley, 2002; Treacy, Kleiman, & Peterson, 2002).

These recommendations emerge from observations of existing OPD programs, surveys gauging the reactions of participants to specific online learning experiences, conceptual comparisons of online and face-to-face learning, and generalizations of principles of effective professional development in face-to-face contexts. To date, we have been unable to identify any research that examines the relationship between specific features of a course that are manipulated and learning outcomes measured by a formal test administered to participants or their students. While these suggestions may be useful to those designing and implementing OPD programs, they are not based on research that empirically demonstrates the effects of specific design features on teacher and student outcomes. Currently, many key questions about how to structure and implement OPD to improve teacher knowledge and practices remain unanswered. To help build this knowledge base, researchers at Education Development Center, Inc (EDC) and the Technology and Assessment Study Collaborative at Boston College

collaborated to conduct a series of studies that focused on how the amount of interaction among participants, the amount and type of facilitation, and the medium of the course (i.e., online or face-to-face) affected the intended outcomes of a given course. This paper presents findings from the first of three studies and was designed specifically to address the following question:

> In an online professional development course designed to improve teachers' content knowledge and abilities to teach algebraic thinking in the middle grades, do teachers who participate in a facilitated online course that includes interacting within a cohort of participants in weekly sessions have different learning outcomes than teachers who work through an online course individually and at their own pace?

An experimental study was conducted to examine how the two different approaches to OPD may affect the goals or intended outcomes of the course, namely increasing teacher content knowledge, altering teachers' pedagogical beliefs, and changing teachers' instructional practices. Thus, the theoretical framework guiding this research holds that: a) online professional development can affect teachers' content knowledge, pedagogical beliefs, and instructional practices; and b) the outcomes of an online professional development course are dependent, in part, upon the level of facilitation and interaction among participants. Based on generally recommended practices for OPD, it was hypothesized that the Facilitated Cohort course would have greater impact than the Self-Paced course on teacher knowledge acquisition and classroom practices.

The Course: Building Algebraic Thinking in the Middle Grades

The course employed for this study was titled *Building Algebraic Thinking in the Middle Grades* and was based on a book authored by Mark Driscoll titled *Fostering Algebraic Thinking* (Driscoll, 1999). The course was developed by mathematics experts at EDC and focused on three important algebraic concepts: patterns, functions, and number sense.

For the study presented here, two versions of the course were provided. Both versions required teachers to read the same material, conduct the same activities in their classroom, and complete the same assignments within a ten-week period. In addition, the courses were run by the same set of two facilitators, each facilitating one session of each version of the course. The intended learning outcomes of the course were also the same for both versions. These outcomes included the following:

- Increased understanding of the concepts of patterns, functions, and number sense;
- Increased ability to identify misconceptions and errors that students apply when working on problems specific to patterns, functions, and number sense;
- Increased ability to identify and apply instructional strategies that hold potential to help improve student understanding of these three concepts;
- Increased use of instructional methods that allow students to develop their own thinking, communicate their understandings, and respond to their classmates' problem solving strategies.

The course activities were divided into 10 sessions, preceded by a brief orientation pre-session to familiarize participants with the technology and course expectations. Sessions contained readings, videos, mathematical activities for the teacher participants, and pedagogical activities, such as preparing a lesson or interviewing students about their mathematics thinking. Depending upon the version of the course, session requirements also included participating in an asynchronous online discussion seeded by specific questions or completing an individual journal entry addressing the same questions. Participants were expected to spend about 4 hours per session, and to complete a final project. The course content is summarized in Table 1 (next page) and the full course is available at: http://www.curriki.org/xwiki/bin/view/Coll_edc1/BuildingAlgebraicThinkingthroughPatternFunctionandNumber-ProfessionalDevelopmentCourseforMiddleGradeMathTeachers.

Table 1: Building Algebraic Thinking in the Middle Grades through Patterns, Functions, and Number Sense

Pre-session: Orientation	You will become familiar with the course format, the facilitators' backgrounds, and what is expected of participants. You will also perform a technology check on your computer to make sure you have the required software.
Session 1: What is Algebraic Thinking?	In this introductory session, you will learn about different definitions of algebraic thinking including the definition used in this course, and compare those definitions to your own. You will also do several math problems that will further clarify the concept of algebraic thinking, and participate in the online discussion on defining algebraic thinking.
Session 2: Exploring Algebraic Thinking in Patterns	In this session, you will focus on your own mathematical thinking when doing pattern problems. An understanding of your thinking will serve as a starting point when you examine student thinking in later sessions.
Session 3: Analyzing Students' Algebraic Thinking about Patterns	This session explores ways to understand students' algebraic thinking by examining their work and discussion in the context of pattern activities.
Session 4: Using Teacher Questioning to Develop Algebraic Thinking	This session is about developing good questioning techniques that help students develop algebraic thinking in the context of pattern activities.
Session 5: Exploring Algebraic Thinking with Functions – Making Generalizations	This session explores how to foster students' algebraic thinking habits as they build generalization skills which are essential to understanding functions.
Session 6: Exploring Algebraic Thinking with Functions – Understanding Graphs	This session explores ways to foster students' algebraic thinking habits as they learn to analyze and interpret graphs of functions.
Session 7: Using Interviews to Analyze Students' Thinking about Functions	This session explores how student interviews are an effective tool for learning about students' algebraic thinking.
Session 8: Exploring Algebraic Thinking with Number Sense – Algorithmic Thinking	This session examines how number strand activities can be used to develop students' algorithmic thinking, an aspect of algebraic thinking.
Session 9: Exploring Algebraic Thinking with Number Sense – Developing Symbol Sense	This session examines how number strand activities can be used to develop students' symbol sense, an aspect of algebraic thinking.
Session 10: Post-Course Survey and Wrap-up	

The two versions of the course differed in the role of the facilitator, whether interactions occurred among participants, and the schedule at which participants worked through the course material. In the Facilitated Cohort version, participants worked through course material together at the same pace and covered one session of the course per week. In addition, these participants were strongly encouraged to interact with their colleagues, via an asynchronous, text-based discussion forum, by posting responses to questions raised by the facilitator and also responding to other participants' comments. For each session of the course, each participant was required to make a minimum of two contributions to the discussion forum. In this version of the course, the facilitator participated in the online discussion, seeking to engage all participants in it, and provided extended feedback to participants nearly every week, and sometimes more often depending upon a participant's learning needs. Thus, the Facilitated Cohort was designed to: a) strongly encourage interactions among participants throughout the course; b) control the pace at which participants worked through the course material; and c) maximize the role of the facilitator in interacting with individual participants and in guiding the development of the cohort as a group.

In the Self-Paced version, participants worked through the course material at their own pace, and were only required to complete all written assignments within a 10 week period. Participants in the Self-Paced course did not have access to a discussion board or any way to contact other course participants. The only communication participants had was with the course facilitator, who provided feedback via email on the assignments completed by participants and did not engage in interactions with participants other than clarifying questions about a given assignment. Thus, the Self-Paced versions was designed to: a) prevent interactions among course participants; b) allow participants to work through the course material at their own pace; and c) minimize the role of the facilitator to only responding to direct questions about assignments and providing feedback on assignments directly to each participant. The study, then, was designed to examine whether learning outcomes, defined by the learning goals for the course, differed when the course was led by a facilitator who played an active role in guiding discussions and strongly encouraged interactions among participants versus a course that was led by a facilitator who responded only to individual questions and assignments and did not allow any interactions among participants.

Study Design

The study presented here was designed to compare the learning outcomes of the same course content delivered as either a Facilitated Cohort or a Self-Paced only course. Two "classes" of each version were provided, with each intended to have up to 25 teachers participate. Two facilitators were hired to run the courses, each with experience providing professional development sessions and training in online teaching. To control for the effect that an individual facilitator may have on the learning outcomes of the course, each facilitator was responsible for one class of each type of course.

Participation in the study was limited to middle school teachers who were currently teaching at least one algebra course. Messages inviting teachers to participate in the study were distributed via a variety of listservs that focus on mathematics instruction or were run by state organizations with whom the researchers had prior working relationships. Ninety-seven public school teachers who responded to the invitation, were currently teaching math to 7th or 8th grade students, and had a working email address were selected to participate in the study. Teachers were then stratified by gender. Forty-eight teachers were randomly assigned to the Self-Paced treatment group and 49 were assigned to the Facilitated Cohort treatment group. Each treatment group was then randomly split again into two classes in order to limit the number of participants in a given class to 25 or fewer.

Participants who completed the course and the data collection instruments were awarded either 5 quarter or 3 semester hours of graduate course credit or a stipend of $200. As described in greater detail below, of the 91 teachers who began the study, 52 met all of the course and data collection requirements.

Data Collection Instruments

Six instruments were employed to collect data about the intended outcomes of the online courses: (1) a background survey, (2) a pedagogical beliefs and practices survey, (3) a measure of teachers' understanding of teaching algebraic concepts, (4) a student survey, (5) a teacher log, and (6) a course evaluation. As shown in Table 2, the background survey, pedagogy survey, teacher log, and the mathematics assessment were administered during a 5 day period prior to the start of the course. The pedagogy survey, mathematics assessment student survey, teacher logs, and course evaluation were administered during a 10 day period following the end of the course. Each of the instruments is described briefly below and the instruments are available online at http://www.bc.edu/research/intasc/researchprojects/optimizingOPD/OPD.shtml.

Table 2: Overview of Instrument Administration

Instrument	Administered Pre-course	Administered Post-course
Background Survey	x	
Pedagogy Survey	x	x
Math Assessment	x	x
Student Survey	x	x
Teacher Log	x	x
Course Evaluation		x

Background Survey

The Background Survey was designed to collect demographic information and information about teachers' prior experiences with professional development and technology use. The majority of the items on the Background Survey were closed-response. In a few instances, participants were requested to type in numeric values. A second set of questions were developed around seven categories. Scales were developed based on theory and were confirmed through principal components analyses. These seven scales and their associated reliabilities included: 1. Confidence in Teaching Math (.85), 2. Instructional Practice (.87), 3. Teaching Experience (.60), 4. Professional Workshops (.56), 5. Teachers' Access to Technology at Home (.79), 6. Teachers' Access to Technology at School (.78), and 7. Technology Use (.78).

The Pedagogy Survey

The Pedagogy Survey collected information about teachers' pedagogical beliefs and instructional practices. All items were closed-ended and asked teachers to either report the frequency with which they employed specific instructional techniques or to indicate the degree to which they agreed or disagreed with a statement that focused on the value of a given instructional practice. The vast majority of items employed for this survey were taken from two previous studies that focused on the relationships between pedagogical beliefs and practices and the use of instructional technology in the classroom (Becker, 1999; Russell, O'Dwyer, Bebell, & Miranda, 2004). The specific scales that were formed and the associated reliabilities included: 1. Teacher Centered Beliefs (.74); 2. Student Centered Beliefs (.66); 3. Instructional Use of Technology (.77); 4. Discussing and Demonstration Solutions (.74); 5. Assigning Higher Order Problems (.58); 6. Assigning Projects (.65); 7. Assigning Worksheets (.60); and 8. Writing About Mathematics (.61).

Math Assessment

The Math Assessment was designed to collect information about teachers' understanding of mathematical concepts covered in the professional development course. The assessment was administered twice, once in the first week and once in the final week. The assessment presented teachers with a sample of student work for a given problem related to patterns, functions, or number sense. The teacher was then asked to respond to a series of questions about the student's work. For each sample, teachers were asked to: a) identify the content and process goals measured by the task the student responded to; b) assess whether the student appears to understand the mathematics required for the problem; c) whether any misconceptions were present in the student's work; d) what more the teacher would like to know about the student's understanding based on the work sample; and e) how the teacher should deconstruct the students' understanding. Using a scoring guide that was shown to yield reliable scores (exact agreement exceeded 85% for all items), two readers independently scored teacher responses and, when discrepancies occurred, the readers discussed their scores before reaching a consensus score. The scoring guide employed the following four point scale: (1) does not meet expectations; (2) partially meets expectations; (3) meets expectations; and (4) exceeds expectations.

Teacher Logs

The Teacher Logs were designed to capture information about teachers' day-to-day pedagogical practices and were intended to document the extent to which teachers employed specific instructional strategies during a given lesson (see teacher log for the specific instructional strategies for which data were collected). The Teacher Logs were administered twice, once in the first week of the course and once in final week of the course. During each administration, teachers were asked to select one class in which they teach algebra and to then complete a log for each of five times the teacher taught that class. Each log consisted of a series of instructional strategies similar to those explored in the course. For each strategy, teachers were asked to indicate whether the strategy was: (1) not used at all; (2) a minor component of the lesson; (3) a major component of the lesson; or (4) the most important component of the lesson. The ratings provided for each activity were then averaged across the logs recorded for each week.

Student Survey

To help triangulate data provided by teachers via the pedagogy survey and the teacher logs, a survey was administered on paper to students in the teacher's algebra classroom. The survey's items asked students to indicate the frequency with which they engaged in specific learning activities (e.g., performing worksheets individually, working with partners to solve problems, sharing solutions with their class, etc.) and how often their teacher employed specific instructional strategies (e.g., asking students to explain how they solved a problem, showing students how to solve a problem, asking students to respond to each others work, etc.). Teachers were asked to administer the survey to the same class selected for the teacher log. Students completed the survey once prior to the course and once following the course. All items were forced-choice and were used to form scales that represent the degree to which students engaged in student-centered activities and in teacher-directed activities. The scale employed for these items ranged from: (1) almost always; (2) most of the time; (3) once in a while; and (4) never. Hence, a low score for a given item indicated more frequent use of the given instructional strategy.

Course Evaluation

The Course Evaluation was designed to collect information from teachers about the positive and negative aspects of the course. The course evaluation instrument asked participants to rate the value and quality of various aspects of the course including the reading material, the assignments, the facilitator, feedback on assignments, etc. (see the course evaluation instrument to view all elements for which data was collected). The Course Evaluation was only administered as a post measure.

Findings

The primary research question examined in this study asked whether the combination of altering the pace with which teachers performed course material and the level of interaction with their peers and the facilitator affected teachers' mathematical understanding, their pedagogical beliefs, and their instructional practices. To this end, the majority of analyses conducted for this study focused on comparing the effect of the two versions of the course on these three outcomes. In addition, to provide a better understanding of characteristics of the study participants, descriptive statistics were calculated for several items on the background survey. Finally, since completion of a professional development course/program may be affected by both the mode of delivery and the characteristics of the program itself (e.g., self-paced versus group facilitation), separate analyses were conducted to examine the effect that the two forms of the course had on attrition. We begin with results of the background survey.

Characteristics of Study Participants

Within each treatment group, the majority of teachers were female (79% for the Self-Paced and 71% for the Facilitated Cohort group). Fifty-one percent of teachers in each treatment group categorized themselves as between the ages of 45 to 59. The Self-Paced treatment group had slightly more teachers in their thirties (26% versus 16%). Thirty-two percent of teachers from the Self-Paced and 33% of teachers from the Facilitated Cohort group indicated that they had been teaching between 1 and 5 years. Nineteen percent of the Self-Paced and 13% of the Facilitated Cohort group indicated they had been teaching for 6 to 10 years. The Self-Paced group had 17% and the Facilitated Cohort group had 16% participants teaching for between 11 and 15 years. Thirty percent of participants in the Self-Paced group taught for 16 years or more and 34% of teachers in the Facilitated Cohort group taught for the same time range. Approximately 2% of participants from Self-Paced and 4% of participants from Facilitated Cohort had taught for less than 1 year at the time of the online course.

Participants in both groups reported similar educational backgrounds and certification status. Twenty-eight percent of Self-Paced and 24% of Facilitated Cohort participants majored in mathematics as undergraduate students. Twenty-one percent of Self-Paced participants and 20% of Facilitated Cohort participants minored in mathematics. In both groups, less than half of the participants had a master's degree. Further, most participates did not have certification in the state in which they taught. Only 26% of Self-Paced participants and 31% of Facilitated Cohort participants were state certified.

A *t*-test was conducted on each of the seven scales to examine whether the treatment groups differed with respect to their confidence in teaching math, instructional practices, teaching experience, professional development experiences, access to technology at home and at school, and their use of technology. No statistically significant differences between the groups for any of these background variables were detected.

Completion Rate

Of the 97 participants who agreed to participate in the study, four did not complete the pre-course background instrument or the other pre-course measures. For this reason, they were dropped from the study before the professional development course began. During the study, an additional 39 (44%) teachers either did not complete the course or did not complete the required post-course data collection instruments resulting in a total of 53 participants. Analysis of those who dropped out of the study indicates that a larger number of participants dropped out of the learning communities group (26) than the Self-Paced group (18). The characteristics of those who dropped out did not differ between the two treatment groups. Follow-up surveys with the drop outs indicated that a large percentage reported they were unable to complete the course due to family health issues, while a smaller number of drop-outs indicated that they found the time requirements of the course too demanding.

The majority of drop-outs were between the ages of 35 and 50. In addition to this age trend, chi-square analyses revealed three other characteristics of teachers who tended to persist versus those who dropped out. First, teachers who either minored or majored in math were more likely to persist through the course. Second, teachers who were certified in math in the state in which they teach were more likely to persist through the course. Finally, teachers who use computers daily or almost daily were more likely to persist through the course. Our interpretation is that this was a demanding course with significant mathematical content, and that teachers who had strong mathematics backgrounds were therefore more likely to complete the course.

Quality of the Online Course

Overall, participants believed that both versions of the course were well developed, well delivered, and valuable. Across all items on the survey that asked participants to rate the value of specific components of the course and the course overall, the mean fell between the valuable and very valuable options. As just one example, when asked to “rate your learning in this course compared to university or college courses you have taken on campus” the mean rating was 3.13, which fell between “slightly more

valuable (3)" and "much more valuable (4)." This mean rating indicates that participants generally felt they learned as much or more in the 10 week online professional development course than they did in their prior university-sponsored courses.

To examine whether participants in the Self-Paced and the Facilitated Cohort groups had similar views about the course, a series of *t*-tests were conducted for each item on the end-of-course evaluation. Without adjusting for multiple comparisons, a statistically significant difference was found for only one item. This item asked participants, "*How valuable did you find reflecting in learning logs*?" The mean for the Self-Paced group was 3.43, which indicated that the group valued the learning logs. The mean for the Facilitated Cohort group was 3.04, which indicated less value for the learning logs. When adjusted for multiple-comparisons, this difference was no longer significant. Collectively, the lack of significant difference between the two groups ratings of the course indicate that the form of the course (i.e., Self-Paced versus Facilitated Cohort) did not seem to influence the participants views of the quality or utility of the course. Overall, the course was highly rated on all aspects by participants in both versions.

Changes in Pedagogical Beliefs

The Pedagogy Survey was designed to collect information about teachers' pedagogical beliefs and practices. The survey was administered pre-and post-course, and the data was used to examine changes in teachers' beliefs and practices that followed their participation in the course. It should be noted that the scales were standardized to have a mean of 0 and a standard deviation of 1. Table 3 (next page) displays the mean scale scores for each treatment group for the pre- and post-course administrations. The column labeled Post-Pre displays the change in mean score between the pre-course and post-course administrations. For both treatment groups, participation in the course appeared to have the strongest effect on teacher-directed beliefs, leading to a large decrease in the strength of those beliefs. Interestingly, the course also appeared to decrease the strength of student-centered beliefs. Together, these changes suggest that the course helped teachers develop more balanced beliefs about the value of teacher-directed and student-centered instructional strategies.

In addition, Table 3 indicates that the course had a slight negative effect on the strength of beliefs about the teacher discussing and demonstrating solutions. Conversely, teachers developed stronger beliefs about the value of assigning higher-order problems and writing about mathematics. The effects for the other variables were inconsistent across the two treatment groups. Of most interest, however, is that the change in teachers'

beliefs differed significantly across the two treatments for only one variable, namely student-centered beliefs. As seen in Table 3, teachers in the Facilitated Cohort group experienced a relatively large change in their beliefs while the change for the Self-Paced group was more moderate.

Table 3: Scale Score Difference Between Pre- and Post-Survey, Grouped by Treatments

	Self-pace N=30			Facilitated Cohort N=23		
	Pre	Post	Post – Pre	Pre	Post	Post – Pre
Teacher Directed Beliefs Scale	0.65	–0.59	–1.24	0.62	–0.70	–1.32
Student Centered Beliefs Scale*	0.14	–0.06	–0.20	0.25	–0.36	–0.61
Technology Use Scale	–0.17	–0.12	0.05	0.28	0.11	–0.19
Discussing or Demonstrating Solutions Scale	0.06	–0.18	–0.23	0.24	–0.08	–0.32
Assigning Higher Order Problems Scale	–0.03	0.13	0.15	–0.16	0.02	0.18
Assigning Projects Scale	0.11	0.08	–0.03	–0.24	–0.01	0.23
Assigning Seat or Homework Scale	0.03	0.21	0.18	–0.14	–0.17	–0.02
Writing about Math Scale	0.02	0.25	0.23	–0.24	–0.12	0.13

* Change scores differed significantly between groups at p = 0.05.

Changes in Instructional Practices

Teachers completed five teacher logs prior to the course and five logs following the completion of the course. As described above, the logs asked teachers to indicate the extent to which each type of activity was a component of the logged lesson. Table 4 (next page) displays the mean ratings given by teachers across lessons logged prior to and following the course. The column labeled post-pre indicates the change in the mean rating between the pre-course logs and the post-course logs. Within the Self-Paced group, the extent to which instructional strategies were elements of lessons changed significantly for six strategies. Three of these strategies – doing introductory drills, working with manipulatives, and working on independent long-term projects – saw declines in their importance. Conversely, three strategies – presenting an answer to a problem in words, debating ideas or explaining reasoning, and working together on problems – experienced increases. For the Facilitated Cohort group, significant changes were found for six strategies. Specifically, four strategies experienced declines – doing introductory drills, working with

manipulatives, working on independent long-term projects, and administering multiple-choice quiz/tests. Four strategies experienced increases – demonstrating/explaining concepts to the whole class, debating ideas or explaining reasoning, working together on problems, and having students respond to each other. Comparisons of change across the two treatment groups revealed no significant differences, suggesting that changes in the extent to which teachers reported the use of each instructional strategy were similar across the two treatments.

Table 4: Summary of Teacher Log Mean Scores by Treatment Group

		Self-paced				Learning Community			
		Pre	Post	Post – Pre	p	Pre	Post	Post – Pre	p
1	I had the students do introductory drills	2.23	1.47	–0.76	<0.01	2.09	1.56	–0.53	<0.01
2	I asked the students to make conjectures	2.19	2.14	–0.05	0.74	1.93	2.16	0.22	0.11
3	I asked the students to present an answer to a problem visually	2.37	2.17	–0.20	0.21	2.33	2.22	–0.01	0.56
4	I asked students to present an answer to a problem with algebraic symbols	2.35	2.31	–0.04	0.85	2.27	2.37	0.10	0.64
5	I asked students to present an answer to a problem in words	1.80	2.22	0.42	0.04	1.88	2.15	0.27	0.11
6	I had students work on or review homework	1.60	1.67	0.09	0.67	1.66	1.76	0.13	0.43
7	I worked with/ demonstrated with manipulatives (i.e. algebra blocks)	2.34	1.49	–0.85	<0.01	2.43	1.82	–0.61	0.01
8	I asked follow-up questions to students' responses to questions	2.17	2.36	0.19	0.21	2.18	2.45	0.27	0.06
9	I led whole class discussions	2.23	2.06	–0.17	0.23	2.26	2.11	–0.15	0.37
10	I demonstrated/ explained concepts to whole class	1.92	2.02	0.10	0.40	1.67	2.06	0.40	0.02
11	I addressed routine or textbook-based problems	1.76	1.62	–0.14	0.40	1.44	1.60	0.16	0.24
12	I used worksheets	1.41	1.50	0.08	0.67	1.26	1.51	0.25	0.06
13	I had students work on independent, long-term projects	1.89	1.45	–0.44	0.01	1.97	1.28	–0.69	<0.01

Table 4: Summary of Teacher Log Mean Scores by Treatment Group (continued)

		Self-paced				Learning Community			
		Pre	Post	Post – Pre	p	Pre	Post	Post – Pre	p
14	I had students develop technical or mathematical writing skills, including equations, graphs, and tables.	2.37	2.03	−0.34	0.10	2.02	1.78	−0.24	0.28
15	I asked students to solve real-world problems	2.28	2.16	−0.13	0.51	2.29	2.01	−0.28	0.06
16	I had students work in pairs or small groups	2.05	2.23	0.18	0.24	2.06	2.29	0.23	0.34
17	I had students work individually	2.19	2.03	−0.16	0.39	2.26	1.99	−0.27	0.25
18	I had students respond to one another	2.13	2.21	0.08	0.55	2.06	2.42	0.36	0.02
19	I had students debate ideas or otherwise explain their reasoning	1.55	2.24	0.69	<0.01	1.68	2.30	0.62	<0.01
20	I had students work together on problems for which there is no immediately obvious method or solution	1.32	1.77	0.45	0.03	1.03	1.82	0.78	<0.01
21	I administered a multiple choice test/quiz	1.32	1.23	−0.09	0.46	1.36	1.06	−0.30	<0.01
22	I administered an open-ended test/quiz	1.44	1.23	−0.21	0.09	1.23	1.29	0.06	0.60

Student Survey Results

Similar to the teacher logs, analyses of the student survey focused on responses to individual items. For each item, the mean response was calculated for each treatment group (Self-Paced and Facilitated Cohort) during each administration period (pre-course and post-course). Recall that the scale was structured such that a low score (1) represented frequent use of the strategy while a high score (4) indicated that the student reported never being exposed to the strategy. Table 5 displays the change in mean response within each group. Within the Self-Paced group, four items saw significant changes in the extent to which students reported their teacher employing a given practice. Three of these practices – explain how I got my answers, using calculators, and using computers – saw significant increases in use. The remaining practice – copying notes from the board – experienced a significant decrease. For the Facilitated Cohort group, sig-

nificant changes were also detected for four items. Three of the instructional practices – explaining how I got my answers, using physical objects, and working on problems that take an entire class to finish – saw significant increases in use. Copying notes from the board saw decreased use.

Examining changes between the students of teachers in the Self-Paced versus the Facilitated Cohort versions of the course revealed two items that differed significantly. For item 14, which focused on the use of worksheets that contain short problems, students in the Self-Paced treatment group reported that their teachers gave worksheets less frequently in the post-survey than in the pre-survey. Students of Facilitated Cohort teachers, on the other hand, reported that teachers gave worksheets more frequently in the post-survey than they reported in the pre-Student Survey. A difference between treatment groups was also found for Item 15, which focused on the use of extended problems. Students of participants in the Self-Paced group moved slightly toward the response *once in a while*. Students of participants in the Facilitated Cohort group moved slightly toward the response, *most of the time*.

Table 5: Mean Score Difference Between Pre- and Post-Surveys, by Treatment Groups

		Self –paced Cohort (25 classrooms, 447 students)				Facilitated Cohort (21 classrooms, 386 students)			
		Pre	Post	Post – Pre	[1]p	Pre	Post	Post – Pre	[1]p
1	My teacher asks me to explain how I got my answers to math problem	1.75	1.59	–0.16	<0.01	1.79	1.69	–0.10	0.05
2	In my math class, my teacher tells us what we need to do to get a good grade on an assignment	1.60	1.65	0.05	0.35	1.59	1.64	0.05	0.37
3	In my math class, we practice things over and over until we get them right	1.83	1.86	0.03	0.47	1.77	1.82	0.05	0.24
4	I work on math problems during classtime with other students in my class	2.25	2.22	–0.03	0.61	2.31	2.26	–0.05	0.27
5	I use physical objects such as cubes and blocks when I am doing math problems	3.23	3.17	–0.06	0.33	3.22	3.03	–0.20	0.01

Table 5: Mean Score Difference Between Pre- and Post-Surveys, by Treatment Groups (continued)

		Self –paced Cohort (25 classrooms, 447 students)				Facilitated Cohort (21 classrooms, 386 students)			
		Pre	Post	Post – Pre	[1]p	Pre	Post	Post – Pre	[1]p
6	The problems we do in math class take an entire class or more to finish	2.67	2.64	–0.03	0.71	2.99	2.82	–0.17	0.03
7	Students help make rubrics (grading guides) that tell us how math work will be graded	3.38	3.35	–0.03	0.77	3.58	3.50	–0.08	0.33
8	In math class, I correct the work that other kids do	3.13	3.14	0.01	0.80	3.35	3.32	–0.04	0.40
9	We copy notes from the board	2.29	2.52	0.23	0.01	2.21	2.38	0.17	0.03
10	I show my work with pictures	3.17	3.12	–0.06	0.43	3.08	3.11	0.03	0.46
11	We have a quiz or a test	2.07	2.13	0.06	0.34	2.01	2.01	–0.01	0.89
12	We use calculators in math class	2.31	2.14	–0.18	0.05	2.04	1.96	-0.08	0.38
13	We use computers in math class	3.29	3.09	-0.20	0.03	3.57	3.56	–0.01	0.89
14*	In math class, our teacher gives us worksheets that have many short math problems	2.35	2.44	0.09	0.21	2.38	2.27	–0.11	0.23
15*	In math class, we work on one or two hard math problems for a long time	2.68	2.78	0.10	0.19	2.81	2.71	-0.10	0.12
16	My teacher show us how to do math problems	1.46	1.57	0.12	0.09	1.37	1.51	0.14	0.10

* Change scores differed significantly between groups with p = 0.05 and adjusted for multiple comparisons.

Mathematics Understanding

To examine the effect that participation in the online professional development course had on teachers' knowledge of teaching mathematics, teachers completed an extended mathematics test that required them to analyze three samples of student work. Table 6 (next page) displays the mean consensus scores awarded for each treatment group for the pre- and post-course test administration.

Within each group, there were increases in scores for the vast majority of items. For the Self-Paced group, score increases were significant for five items, namely item 1.4, 1.5, 2.4, 3.1 and 3.4. For the Facilitated Cohort group, score increases were significant for four of the same items, namely 1.4, 2.4, 3.1 and 3.4. It is interesting to note that in all cases teachers were able to provide stronger responses to the fourth prompt, which asked what they were left wondering about each student's understanding and how they would find out. When comparing the degree of change experienced across the two groups, a significant difference was found for only one item, namely 3.4. While both groups saw significant score increases, the magnitude of the increase was significantly larger for the Facilitated Cohort group.

Table 6: Mean scores for Pre and Post tests by Treatment Group

		Self-paced					Learning Community				
		N	Pre	Post	Post – Pre	p[1]	N	Pre	Post	Post – Pre	p[1]
Task 1.1	Identify the Content and Process Goals of this patterns problem.	30	1.90	2.17	0.27	0.13	23	2.13	2.52	0.39	0.10
Task 1.2	What do you think each student understands about the mathematics of this problem? What is your evidence?	30	2.97	2.93	–0.03	0.85	23	2.83	2.87	0.04	0.82
Task 1.3	What, if any, misconceptions do these students show?	30	2.53	2.63	0.10	0.61	23	2.70	2.65	–0.04	0.82
Task 1.4	What are you left wondering about each student's understanding and how would you find out?	30	2.20	2.80	**0.60**	**0.01**	23	2.26	2.57	**0.30**	**0.05**
Task 1.5	How would you deconstruct any misconceptions these students appear to have?	30	2.40	2.97	**0.56**	**0.01**	23	2.26	2.48	0.22	0.29
Task 2.1	Identify the Content and Process Goals of this Functions problem.	30	1.97	2.10	0.13	0.21	23	1.91	2.00	0.09	0.49
Task 2.2	What do you think each student understands about the mathematics of this problem? What is your evidence?	30	2.57	2.87	0.30	0.11	23	2.39	2.52	0.13	0.54

Table 6: Mean scores for Pre and Post tests by Treatment Group (continued)

		Self-paced					Learning Community				
		N	**Pre**	**Post**	**Post – Pre**	**p[1]**	**N**	**Pre**	**Post**	**Post – Pre**	**p[1]**
Task 2.3	What, if any, misconceptions do these students show?	30	2.47	2.27	–0.20	0.23	23	2.22	2.04	–0.17	0.46
Task 2.4	What are you left wondering about each student's understanding and how would you find out?	30	1.77	2.30	**0.53**	**<0.01**	23	1.70	2.30	**0.61**	**0.02**
Task 2.5	How would you deconstruct any misconceptions these students appear to have?	30	2.03	2.23	0.20	0.30	23	1.78	2.17	0.39	0.07
Task 3.1	Identify the Content and Process Goals of this Number Sense problem.	30	1.93	2.43	**0.50**	**0.01**	23	1.87	2.43	**0.57**	**<0.01**
Task 3.2	What do you think each student understands about the mathematics of this problem? What is your evidence?	30	2.43	2.53	0.10	0.56	23	2.35	2.30	–0.04	0.77
Task 3.3	What, if any, misconceptions do these students show?	30	2.47	2.40	–0.07	0.69	23	2.30	2.43	0.13	0.45
Task 3.4	**What are you left wondering about each student's understanding and how would you find out?**	30	1.90	2.33	**0.43**	**0.02**	23	1.74	2.74	**1.00**	**<0.01**
Task 3.5	How would you deconstruct any misconceptions these students appear to have?	29	2.03	2.24	0.17	0.46	23	2.09	2.43	0.35	0.15

[1] P value for dependent *t* test: Whether difference between post and pre scores is significant different from zero.

Discussion and Summary

This experiment examined the effects that specific design features of an online professional development course have on the perceived value of the course and the intended learning outcomes. The specific design features examined included the pace of the course and the level of interaction among participants and with the course facilitator. In the Self-Paced version, participants worked through course readings and assignments at their own pace, with minimal interaction via email with the course facilitator. In many respects, the Self-Paced version was similar to a guided self-study course that contained specific activities and writing assignments participants are expected to complete. In the Facilitated Cohort version, participants worked through the material together in weekly sessions and were required to interact with each other in an online discussion forum. In this version, the course facilitator was also proactive in communicating with participants and often initiated interactions with and among participants by posting questions to the group or directly emailing individual participants.

The intended learning outcomes of both courses, however, were identical. Specifically, *The Building Algebraic Thinking in the Middle Grades* online professional development course was intended to change teachers' pedagogical beliefs, level of understanding, and practices when teaching algebra. To examine the effect that this OPD course had on these three outcomes, several data collection instruments were employed. A mathematics test was used to measure changes in teachers understanding of teaching algebra. A survey was used to measure teachers' pedagogical beliefs. And the combination of a teacher survey, student survey, and instructional logs were used to measure teachers' instructional practices.

As described in greater detail above, both conditions of the course appear to have been effective in altering teachers' pedagogical beliefs, changing their instructional practices, and increasing their understanding of teaching algebra. On average, teacher-directed and student-centered pedagogical beliefs both weakened, and instead teachers appeared to recognize that a balanced approach to instruction was valuable. Teachers also appeared to decrease their value and use of worksheets, multiple-choice quizzes, and direct instruction, while increasing opportunities for students to discuss their problem solving strategies, write about mathematics, and engage in more extended, higher-order problem solving activities. These changes in practices were reported across the teacher survey, student survey, and the instructional logs. Finally, teachers' understanding of algebra teaching also increased, particularly with respect to understanding how to probe student work to better understand the thinking behind students' answers, even when the answers were incorrect. Each of these out-

comes is not surprising, particularly since teachers, on average, rated the quality of the course as high and reported that they learned more from this ten week online course than they typically learned in college or university courses.

What is surprising, however, is that the effects of the course on the intended outcomes generally did not differ significantly between the two versions of the course. On the mathematics test, there was only one item for which a significant group difference was detected, but even for this item, both groups realized significant gains. With respect to pedagogical beliefs, only one item showed a significant difference between the two groups, but here again significant change occurred with both groups, but was larger for the Facilitated Cohort group. Finally, the instructional logs revealed no significant changes between the two groups, while the student survey showed only two items that differed significantly. These two items focused on the use of extended versus shorter mathematical problems to help develop students' learning. Given the large number of scales and individual items analyzed, the fact that significant differences were detected for only one scale and four items provides evidence that the Self-Paced and the Facilitated Cohort versions of the course had approximately the same affect on the intended outcomes of the course.

This finding is surprising given the emphasis in the literature on the importance of interactions among peer participants in online courses. While substantial interaction occurred in the Facilitated Cohort group, absolutely no interaction among participants occurred in the Self-Paced course. Yet, the outcomes were nearly identical. Similarly, the literature emphasizes the importance of online facilitation, a time consuming task that requires skill in managing discussions and personalities. Both the Facilitated Cohort classes were led by seasoned facilitators who were experienced mathematics teachers and who have received high ratings in previous courses. The facilitators reported investing considerable time each week (averaging at eleven hours) interacting with participants, and managing online discussions. While these same facilitators also led the Self-Paced course, the structure of those sessions did not require, or even allow, them to manage discussions. Although one of the facilitators did engage in multiple email exchanges with a few participants, the time invested in facilitating the Self-Paced course was substantially smaller (an average of three and a half hours per week), and focused primarily on providing feedback on completed assignments. Thus, given the skill and time required, as well as the associated cost for facilitating a Facilitated Cohort course, the fact that both versions of the course yielded similar positive effects on participants suggests that a well designed online course may not need as much facilitation or interaction to produce the same types of learning outcomes.

These findings, however, must be placed in the context of several limitations of this study. First, the study focused on only one course delivered only to middle school mathematics teachers. Had a different course that focused on different types of teachers or different content been employed, the outcomes may have been different.

Second, both versions of the course experienced considerable attrition. On average, 44% of the teachers who began a course did not finish the course or the required data collection instruments. While the literature is mixed with respect to retention rates for online professional development, the fact that 44% of teachers did not complete the course may mean that the course either did not meet their needs or was too challenging for them. Although the characteristics of teachers who dropped out of the course did not differ between the two versions, it is plausible that had these teachers persisted, different findings may have resulted.

Third, the course employed for this study was very well designed and employed a high-quality text. In addition, the course lasted for ten weeks. While the quality of the course was not compared to other online courses, it is likely that many other courses are of shorter duration, employ lower quality reading material, or ask participants to engage in less effective classroom activities. For a course that is shorter in length or that employs materials of a lower quality, interactions among participants may provide valuable supplemental opportunities for learning. Thus, had this study employed a shorter course or a course that employed lower quality materials and activities, different findings may have resulted.

Finally, all of the participants in this course were volunteers. Although a small stipend was offered to compensate participants for the time required to complete the data collection instruments, the teachers who participated and completed the course were likely highly motivated individuals who were sincerely interested in developing their algebraic teaching skills. In many cases, however, participation in professional development is required by a school or district. In such cases, some teachers may be less motivated and engaged in the learning. If presented with a self-paced version of the course, some of these teachers might be unmotivated to complete the reading and activities, and may make a minimal effort when completing assignments. The resulting effects of the course might then be smaller.

Despite these limitations, this study provides preliminary evidence that an online course designed as a self-study may be equally effective as one that moves an interactive Facilitated Cohort together through a series of readings, activities, and assignments. Future studies may wish to explore this issue using different courses, content areas, and approaches to participant recruitment. In addition, it would be informative to examine whether

even more extreme differences in the level of interaction and facilitation affected the outcomes of the course. What is clear here, though, is that an online professional development course can have very positive effects on teachers' knowledge, pedagogical beliefs, and instructional practices, and that the magnitude of these effects may not always differ between courses that are designed to occur as Self-Paced or as Facilitated Cohort learning opportunities.

References

Anderson, A.-C. (2002). Just because it's online doesn't mean it's learner-centered. In A. Thorson (Ed.), *By your own design: A teacher's professional learning guide* (pp. 37–38). Columbus, OH: Eisenhower National Clearinghouse for Mathematics and Science Education.

Ball, D.L. (2002, October). *What do we believe about teacher learning and how can we learn with and from our beliefs*? Paper presented at the Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education, Athens, GA.

Ball, D.L., & Cohen, D.K. (1999). Developing practice, developing practitioners: Toward a practice-based theory of professional education. In G. Sykes & L. Darling-Hammond (Eds.), *Teaching as the learning profession: Handbook of policy and practice* (pp. 3–32). San Franciso: Jossey-Bass.

Barab, S.A., MaKinster, J.G., & Scheckler, R. (2003). Designing system dualities: Characterizing a web-supported professional development community. *The Information Society, 19*, 237–256.

Becker, H. (1999). Internet use by teachers: Conditions of professional use and teacher-directed student use. Irvine, CA: Center for Research on Information Technology and Organizations.

Dalgarno, N., & Colgan, L. (2007). Supporting novice elementary mathematics teachers' induction in professional communities and providing innovative forms of pedagogical content knowledge development through information and communication technology. *Teaching and Teacher Education, 23*, 1051–1065.

Darling-Hammond, L. (1997). *Doing what matters most: Investing in quality teaching*. New York: National Commission on Teaching & America's Future.

Dede, C. (Ed.). (2006). *Online professional development for teachers: Emerging models and methods*. Cambridge, MA: Harvard Education Press.

Docherty, A., & Sandhu, H. (2006). Student-perceived barriers and facilitators to e-learning in continuing professional development in primary care. *Education for Primary Care, 17*, 343–353.

Driscol., M. (1999). Fostering Algebraic Thinking: A Guide for Teachers, Grades 6–10. Boston, MA: Heinemann.

DuFour, R. (2002). Taking on loneliness. In A. Thorson (Ed.), *By your own design: A teacher's professional learning guide* (pp. 24–25). Columbus, OH: Eisenhower National Clearinghouse for Mathematics and Science Education.

Florida Instructional Technology Resource Center at UCF. (2000). *Online staff development: Lessons learned from developers, from facilitators, from participants*. Orlando, FL: Florida Department of Education Bureau of Educational Technology.

Galley, M. (2002). E-training offers options. *Education Week, 21*(35), 41–44.

Garrison, R.D., & Cleveland-Innes, M. (2005). Facilitating cognitive presence in online learning: Interaction is not enough. *American Journal of Distance Education, 19*(3), 133–148.

Hargreaves, A. (1994). *Changing teachers, changing times: teachers' work and culture in the postmodern age*. New York: Teachers College Press.

Henderson, M. (2007). Sustaining online teacher professional development through community design. *Campus-Wide Information Systems, 24*(3), 162–173.

Hur, J.W., & Hara, N. (2007). Factors cultivating sustainable online communities for K–12 teacher professional development. *Journal of Educational Computing Research, 36*(3), 245–268.

Keller, B. (2005, July 27). Teachers flocking to online sources to advance and acquire knowledge. *Education Week, 24*, 22–24.

Lim, B.-R. (2004). Challenges and issues in designing inquiry on the Web. *British Journal of Educational Technology, 35*(5), 627–643.

Loucks-Horsley, S. (1995). Professional development and the learner centered school. *Theory into Practice, 34*(4), 266–271.

Louis, K.S., & Marks, H.M. (1998). Does professional community affect the classroom? Teachers' work and student experiences in restructuring schools. *American Journal of Education, 106*(4), 532–575.

National Staff Development Council. (2001). *E-learning for educators: Implementing the standards for staff development*. Oxford, OH.

Nickerson, S.D., & Sowder, J.T. (2002, July). *What factors influence the formation of teachers' professional communities and why should we care*? Paper presented at the Annual Meeting of the International Group for the Psychology of Mathematics Education, Norwich, England.

Phipps, R., & Merisotis, J. (1999). *What's the difference? A review of contemporary research on the effectiveness of distance learning in higher education*: Institute for Higher Education Policy.

Renyi, J. (1996). *Teachers take charge of their learning: Transforming professional development for student success*. Washington, DC: National Foundation for the Improvement of Education.

Richardson, J. (2002). E-learning potential: Online staff development has great possibilities – and pitfalls. In A. Thorson (Ed.), *By your own design: A teacher's professional learning guide* (pp. 12–13). Columbus, OH: Eisenhower National Clearinghouse for Mathematics and Science Education.

Russell, T.L. (1999). *The no significant difference phenomenon*. Chapel Hill, NC: North Carolina State University.

Russell, M., O'Dwyer, L., Bebell, D., & Miranda, H. (2004). Technical Report for the USEIT Study. Chestnut Hill, MA: Technology and Assessment Study Collaborative. Available online at: http://www.intasc.org/PDF/useit_r11.pdf.

Schlager, M., Fusco, J., & Schank, P. (2002). Evolution of an online education community of practice. In K. A. Renninger & W. Shumar (Eds.), *Building virtual communities: Learning and change in cyberspace*. New York: Cambridge University Press.

Schulman, L.S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1–22.

Scotchmer, M., McGrath, D.J., & Coder, E. (2005). *Characteristics of public school teachers' professional development activities: 1999-2000*: National Center for Education Statistics.

Sparks, D. (2002). Dreaming all that we might realize. In A. Thorson (Ed.), *By your own design: A teacher's professional learning guide* (pp. 18–23). Columbus, OH: Eisenhower National Clearinghouse for mathematics and Science Education.

Spicer, J. (2002). Even better than face-to-face? In A. Thorson (Ed.), *By your own design: A teacher's professional learning guide* (pp. 32–33). Columbus, OH: Eisenhower National Clearinghouse for Mathematics and Science Education.

Stigler, J., & Hiebert, J. (1999). *The teaching gap: Best ideas from the world's teachers for improving education in the classroom*. New York: The Free Press.

Treacy, B., Kleiman, G., & Peterson, K. (2002). Successful online professional development. *Leading & Learning with Technology, 30*(1), 42–47.

Whitehouse, P.L., Breit, L.A., McCloskey, E.M., Ketelhut, D.J., & Dede, C. (2006). An overview of current findings from empirical research on online teacher professional development. In C. Dede (Ed.), *Online professional development for teachers: Emerging models and methods* (pp. 13–29). Cambridge, MA: Harvard Education Press.

Willis, S. (2002, March). Creating a knowledge base for teaching: A conversation with James Stigler. *Educational Leadership, 59*, 6–11.

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Glenn Kleiman is Executive Director of the Friday Institute for Educational Innovation and Professor of Educational Leadership and Policy Studies at the NC State University College of Education. A cognitive psychologist by background (Ph.D., Stanford, 1977), his work in education has spanned basic and applied research, curriculum development, software development, providing professional development for teachers and administrators, policy analyses, and consulting for school districts and state departments of education. Prior to joining NC State in July 2007, he was, since 1985, Vice President and Senior Research Scientist at Education Development Center, Inc. (EDC) in Newton MA, where he most recently directed the Center for Online Professional Education and was Co-Director of the Northeast and Islands Regional Education Lab. Previously at EDC, he directed the development of the MathScape: Seeing and Thinking Mathematically in the Middle Grades curriculum, which was funded by NSF and published by Glencoe/McGraw Hill, as well as many other projects in educational technology and mathematics education. He was also on the faculty of the Harvard Graduate School of Education from 1995-2007 and was educational chair of the Harvard/EDC Leadership and the New Technologies Institutes, held each summer at Harvard from 1997–2001. Dr.. Kleiman has also been a faculty member in psychology and in education at the University of Illinois, the

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Joanne Douglas Venable was a Research Associate for inTASC who worked primarily on the Optimizing the Impact of on Online Professional Development study. Prior to this research, Joanne was a teacher in Boston Public Schools. Her research interests include the use of student drawings to determine student attitudes toward math, the effects of online professional development on teacher practice, and examining the impact of professional development for teachers of diverse populations. Joanne Douglas Venable can be reached via email at jldouglas31@hotmail.com.

Josephine Louie is a Research Associate at the Regional Educational Laboratory – Northeast and Islands (REL-NEI) at EDC, where she serves as a principal investigator and an author of studies funded by the Institute of Education Sciences. Dr. Louie (Ed.D, Harvard, 2006) has conducted research on virtual learning environments, the educational impacts of electronic media among youth, and immigrant acculturation and the racial attitudes of racial and ethnic minorities. Josephine Louie can be reached via email at jlouie@edc.org.

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